Composition and Diversity of Forestry Plant Species in Forest Areas Manado State University, North Sulawesi

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Abstract: Indonesia is an archipelagic country with a tropical climate so it has a large forest area. High rainfall and sufficient solar irradiation make the diversity of living things both flora and fauna very high. This study aims to identify and determine the level of diversity of forestry plants in the forest area of Manado State University, North Sulawesi. This research will be carried out in April - May 2023 in the forest area of Manado State University, North Sulawesi. Sampling in this study was carried out using the Purposive Sampling (Judgmental Sampling) technique with 9 plots in 3 observation stations. The results of the study found that in all sampling plots, there were 17 individuals of forestry plants with 9 species. The highest Important Value Index (IVI) belongs to the species Petrocarpus indicus with an IVI of 61%. The Shannon Winner diversity index H = 2.07 was found to be in the medium category.

Keywords: Composition; Diversity; Forestry crops; Important value index

Introduction

Indonesia is an archipelago located at a geographical location of 6°N- 11°S and 95°- 140°BT which makes it one of the countries with a tropical climate in the world. High rainfall and sufficient sunlight make the diversity of living things found in almost all parts of the Indonesian archipelago. This condition allows a high level of diversity of living things both flora and fauna, making Indonesia the second country with the highest level of biodiversity after Brazil (Isnaini et al., 2015).

Biodiversity is a statement of the wide variety of phenotypes such as shape, color, appearance, and various other traits in each level of life organization structures, namely genes, species, and ecosystems (Febriana et al., 2022). The diversity of species that live in a place can be used as an indicator of assessing the quality or condition of the ecosystem itself. Therefore, exploration efforts must continue to be carried out to identify the types or species in an ecosystem, the level of diversity, and the most appropriate conservation efforts for biological types in an ecosystem as an effort to preserve nature.

A forest is a combination of ecosystems in the form of land dominated by biological resources in the form of trees that have inseparable interactions with their environment. Forests have a major role in maintaining the stability of an area. The forest is a natural environment and ecosystem with its main function as a home for various living things. Forest activities are supported by the combination of existing species with their relative abundance to provide various essential elements in life including carbon, oxygen, nitrogen, and so on (Naisumu, 2018). Forestry plants that grow in the forest will vary in type according to the natural conditions in the environment, this can then also be used as a parameter of the environmental quality of an area.

Manado State University in North Sulawesi Province is a University with an area of 270 hectares or 2,700,000 square which has several points of forestry areas in it. Seeing the benefits of forests for living things,

it is necessary to conduct specific explorations to identify and obtain information about biological resources in the form of forestry plants or trees in this area. By knowing the composition of forestry plants in this area, a graph of the percentage of forestry plants will be obtained which will then be analyzed for the level of diversity, the index of important value (IVI) to determine the dominance of a plant species, dominance index, species richness, and evenness and other biotic factors that influence. Knowing the composition, level of diversity, and important value index (IVI), will make it easier for related parties to process and utilize forestry areas to the maximum. This is then the background of the purpose of this research, namely to identify and determine the level of diversity of forestry plants in the forest area of Manado State University, North Sulawesi, Indonesia.

Method

This research was conducted from April to May 2023 in the forest area of Manado State University, North Sulawesi. Sampling in this study was carried out using the Purposive Sampling (Judgmental Sampling) technique, which is a sampling technique by determining the choice of samples intentionally based on the quality and information possessed by the sample that meets the data needs of the researcher (Etikan, 2016). In this study, 3 sampling stations were determined, namely the Faculty of Economics' forest area, the Faculty of Mathematics, Natural and Earth Sciences' forest area, and the Faculty of Sport Science and Public Health's forest area. At each station, 3 sampling plots measuring 50 m x 50 m were determined on 1 transect line so that for the three different research stations there were a total of 9 sampling plots.

The research procedure begins with field activities, namely making observations at each sampling station, recording and calculating the circumference of the identified tree trunk, and documenting each species obtained. Furthermore, the samples were identified by converting the images into the Google Lens application to determine the classification of each plant encountered. Calculation of supporting parameters of light intensity environmental factors using the Lux Light Meter application. Stationery is used to write data in the field.

The research data were then analyzed quantitatively to determine the percentage of forestry plants by presenting graphs, the level of diversity, and important value index (IVI) as well as indices of dominance, richness, and evenness of species by displaying scientific name data, tables, and calculation results. While qualitative analysis is in the form of a description of each type and species and other supporting factors.

The important value index (IVI) is used as a parameter to express the level of mastery or dominance of species in forest communities (Rahmawati et al., 2022).

Important Value Index (IVI) of the plants was determined through calculation using the equation 1:

$$IVI = RF + RD + RD \tag{1}$$

Where to get the density value the following equation is used:

$$AD = \frac{numbers\ of\ individu\ of\ a\ species}{total\ area\ sampled} \tag{2}$$

$$RD = \frac{density\ of\ a\ species}{total\ density\ of\ all\ species} \times 100\% \tag{3}$$

While the frequency value is calculated as follows:

$$AF = \frac{area\ of\ plots\ in\ which\ a\ species\ occurs}{total\ area\ sampled} \tag{4}$$

$$RF = \frac{frequency\ of\ a\ species}{total\ frequency\ of\ all\ species} \times 100\% \tag{5}$$

$$dominance = \frac{total\ basal\ of\ a\ species}{total\ area\ sampled} \tag{6}$$

$$RD = \frac{dominance\ of\ a\ species}{total\ dominance\ of\ all\ species} \times 100\% \tag{7}$$

Where: IVI = Important value index; AF = Absolute frequency; RF = Relative frequency; RD = Relative Density & Dominance; AD = Absolute Density (Wiryono, 2020).

Species diversity is expressed through the Shannon Winner diversity index with the following Equation 8:

$$H' = -\sum pi\ \ln pi \tag{8}$$

where pi is the proportion of the number of individuals of the i-th species to the total number of individuals (Magurran, 1988). The dominance index is obtained from the calculation using the following equation 9 (Odum, 1996).

$$D = \frac{ni}{N} \tag{9}$$

Where :
D : Dominance Index
ni : number of a species
N : total individuals of all species

The richness index is calculated with the following Equation 10:

$$\text{Dmg} = \frac{S-1}{\ln(S)} \qquad (10)$$

Where:
Dmg : Margalef Richness Index
S : Number of species found
Evenness index obtained from the calculation using the equation 11:

$$E = \frac{H\prime}{\ln(S)} \qquad (11)$$

Where :
E : Evenness Index
H′ : Diversity Index
S : Number of individual of all species

Result and Discussion

Identification of Forestry Plants in Manado State University's Forest Area

Based on observations at three stations with 9 sampling plots, namely the forest area of the Faculty of Economics, Faculty of Mathematics, Natural, and Earth Sciences, and the Faculty of Sports Sciences, Manado State University, there were 17 individual forestry plants divided into 9 species with 9 different families. The list of species and number of species is attached in Table 1. The data in Table 1 shows that station 1 of the Faculty of Economics has the most different types or species with 5 types of plants while station 3 of the Faculty of Sport Science has the least number of different species, namely 1 species. Meanwhile, when viewed from the total number of individuals at each observation station, it was found that station 2 of the Faculty of Mathematics, Natural Sciences, and Earth are the stations with the most individual plants, namely 10 individuals.

The distribution of species among families was eneven (Luna-Kamyshev et al., 2020). As seen from the number of individuals in each species found that the species with the most individuals is *Petrocarpus indicus* with 10 individuals, while *Mangifera indica, Lansium domesticum, Ficus benjamina,* and *Gmelina arborea* are the species with the least number of individuals with 1 individual in each species.

Composition of Species

The composition of forestry plant species in the Universitas Negeri Manado forest area is presented in the form of a graph of the percentage of each forestry plant species in the entire observation area which can be seen in Figure 1.
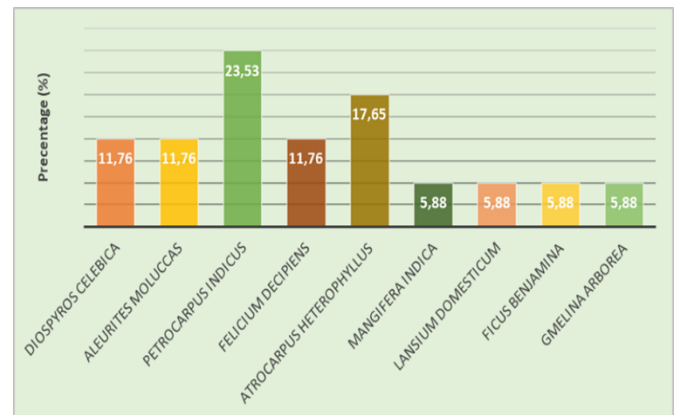

Figure 1. Percentage of number of species

Based on the graph of the percentage of forestry plant species in Figure 1, it can be seen that according to the number of individuals in a species, *Petrocarpus indicus* has the highest percentage of 23.53% while the least percentage is plants with species *Mangifera indica, Lansiumdomesticum, Ficus benjamina* and *Gmelina arborea* totaling 5.88%. Table 1 also shows that some forestry plant species only occupy a station or plot and are not found at other stations. Plants found only at station 1 include *Mangifera indica, Lansium domesticum, Ficus benjamina,* and *Gmelina arborea.* Plants that are only found at station 2 include *Aleurites moluccas, Petrocarpus indicus,* and *Felicium decipiens.* While the species that are only found at station 3 is *Diospyros celebica* which is a single species.

Table 1. List of Forestry Plat in Manado State University

Local Name	Scientific Name	Family	Station 1	Station 2	Station 3	Total
Kayu hitam	*Diospyros celebica*	*Ebenaceae*		1	1	2
Kemiri	*Aleurites Moluccas*	*Euphorbiaceae*	2			2
Angsana	*Petrocarpus Indicus*	*Fabaceae*	2 2			4
Kerai payung	*Felicium Decipiens*	*Sapindaceae*	2			2
Nangka	*Atrocarpus Heterophyllus*	*Moraceae*	1	2		3
Mangga	*Mangifera indica*	*Anacardiaceae*	1			1
Langsat	*Lansium domesticum*	*Meliaceae*	1			1
Beringin	*Ficus benjamina*	*Moraceae*	1			1
Jati putih	*Gmelina arborea*	*Lamiaceae*	1			1
Total						17

Important Value Index (IVI)

The results of vegetation analysis on all 9 observation plots at 3 different stations obtained a total number of individuals 17, with 9 species and families (Table 1). Based on the results of quantitative analysis to find the Index of Important Value (IVI) of a plant species, the highest value was obtained between the species found at the three sampling stations, namely *Petrocarpus indicus* with an IVI of 61%, followed by *Diospyros celebica* and *Atrocarpus heterophyllus* with IVI of 49.57% and 48.89% (Figure 2). Meanwhile, the plant with the lowest Importance Value Index (INP) is Lansium domesticum with a value of 16%. Complete data on the list of important value indices of forestry plants in the Manado State University forest area can be seen in Table 2.

Table 2. Important Value Index (IVI)

Scientific Name	RD (%)	RF (%)	RD (%)	IVI (%)
Diospyros celebica	11.76	16.67	21.14	49.57
Aleurites Moluccas	11.76	8.33	18.19	38.29
Petrocarpus Indicus	23.53	16.67	20.81	61.00
Felicium Decipiens	11.76	8.33	7.25	27.35
Atrocarpus Heterophyllus	17.65	16.67	14.58	48.89
Mangifera indica	5.88	8.33	8.39	22.61
Lansium domesticum	5.88	8.33	1.79	16.00
Ficus benjamina	5.88	8.33	4.86	19.07
Gmelina arborea	5.88	8.33	3.00	17.22

The calculation of the Important Value Index (IVI) is used to describe the level of distribution and dominance of each species identified in the field (Naemah et al., 2020). Angsana or *Petrocarpus indicus* has the highest IVI which means that this plant grows dominantly because it is best able to adjust to the environmental conditions of the growing location. This is influenced by the condition of the plant. Angsana itself has the ability and suitability to grow in areas with tropical and sub-tropical climates with temperatures ranging from 22-32°C (Danarto, 2013) where the location of the sampling station has conditions that are very suitable for ideal growing conditions for this species. Another factor is also because Angsana plants in this area are found at Faculty of Mathematics, Natural and Earth Sciences station whose environment tends to have higher humidity than other observation stations, thus providing growth opportunities for the species.

Some types of fungi, one of which is FMA or *Arbuscular mycorrhizal* Fungi, are known to have a symbiotic mutualism relationship with several plants including Angsana *Petrocarpus indicus* (Arif et al., 2018) which makes Angsana have a good growth in these conditions. While other plants with a lower Index of Importance (IVI) do not dominate the cultivated land, which means that these plants are not yet included as main plants or only as intercrops that grow wildly and

have not been cultivated in the area (Nurlaila et al., 2021).

Table 1 shows that the species with the second highest number of individuals is *Atrocarpus heterophyllus* with 3 individuals but Table 2 states that the species has the third highest Important Value Index (IVI) score. This is because the determination of the level of mastery of a species over other species is not only determined by the number of species but is a combination of the density, frequency, and dominance of a species (Kainde et al., 2011). In this study, this is because *Diospyros celebica* has a larger stem diameter than *Atrocarpus heterophyllus*, making the species superior in relative dominance value allowing the species to have a greater IVI score than *Atrocarpus heterophyllus* which has more individuals.

Figure 2. Species with the Highest IVI Score: a) *Petrocarpus indicus*, b) *Diospyros celebica*, c) *Atrocarpus heterophyllus*.

Shannon Winner Diversity Index (H')

The species diversity index of forestry plants at all sampling stations or plots in the Manado State University's forest area is listed in Table 3. The diversity index allows describing the relationship between the number of species and the number of individuals in a community. Based on the data in Table 3 the results of the quantitative analysis of Shannon Winner (H'), the diversity index of forestry plants identified at each observation station is included in the medium category with a diversity index of H = 2.07. This is concluded by the results of the calculation using the formula are matched with Shannon Winner's statement about the level of diversity, if H'<1 the level of diversity is in a low category, then if 1<H'<3 the species diversity is moderate and H'>3 means high diversity. In Table 3, it is stated that the results of the calculation of the diversity index of forestry plants in the Manado State University forest area are H = 2.07 which is included in the medium category with the number of species of 9 and 17 individuals. Differences in conditions and environmental factors affect the distribution and relationships between species in an area. At the same time, the area and distribution of observation locations affect the number of species identified.

Table 3. Diversity Index of Forestry Plant in Manado State University

Local Name	Scientific Name	Family	Pi	Ln Pi	Pi LnPi
Kayu hitam	*Diospyros celebica*	*Ebenaceae*	0.12	-2.14	-0.25
Kemiri	*Aleurites Moluccas*	*Euphorbiaceae*	0.12	-2.14	-0.25
Angsana	*Petrocarpus Indicus*	*Fabaceae*	0.24	-1.45	-0.34
Kerai payung	*Felicium Decipiens*	*Sapindaceae*	0.12	-2.14	-0.25
Nangka	*Atrocarpus Heterophyllus*	*Moraceae*	0.18	-1.73	-0.31
Mangga	*Mangifera indica*	*Anacardiaceae*	0.06	-2.83	-0.17
Langsat	*Lansium domesticum*	*Meliaceae*	0.06	-2.83	-0.17
Beringin	*Ficus benjamina*	*Moraceae*	0.06	-2.83	-0.17
Jati putih	*Gmelina arborea*	*Lamiaceae*	0.06	-2.83	-0.17
					H = 2.07

IVI the *Pterocarpus indicus* this study is 61%, recharche, Riana et al. (2022) IVI: 22.5% and Noviani et al. (2018) IVI: 4.3%. In contras to research carried out of the Univerty of Mataram, it was found that Fabaceae was the dominant species, while based on the overall recapitulation of species based on family, Araceae dominated (Latifah et al., 2021). Tallei et al. (2016) has presented IVI 127.08% for *Spathodea campanulata* and IVI: 242.90%, Pinus in natural forest Wono Lestari (Jatmiko et al., 2020). Phenomenon the high and low diversity index of a community is determined by the number of individuals of each species. The individual abundance of each species reflects the degree of vegetation (Anbarashan et al., 2013).

Dominance, Richness, and Evenness Index of Species

In an ecosystem, all species depand on each other either directly or indirectly even though the various species share different resources for the survival of each species (Birkhofer et al., 2018). Ecosystems with more diverse species are consided more efficient, productive and sustainable (Huang et al., 2021). Par example in Klamono forestry Sorong, dominance trees is matoa (Liarian et al., 2023), *Palaquium gutta* at Bolaang Mongondo (Umawaitina et al., 2019), *Spathodea campanulata* in Tangkoko Forestry Bitung (Mewengkang et al., 2022) and *Trema orientalis* in Minahasa Selatan (Wahyuni et al., 2016).

Indices of dominance, richness, and evenness of forestry plant species at all sampling stations or plots in the Universitas Negeri Manado forest area are listed in Table 4. Based on the results of quantitative analysis on all sampling plots The dominance index (C) was obtained with a value of 0.14. This shows that in the Manado State University's forest area, the level of dominance of species is in a low category, which means that it has a diffuse pattern of dominance so that each species in the community has a balanced mastery ability (Alhani et al., 2015). Heterogeneous communities such as in forests mostly have a low dominance index, stating that all species found in that location have a relatively equal or evenly distributed opportunity to maintain the sustainability of their species (Febriana et al., 2022).

The diversity of species in this study is classified in the medium category with a diversity index of H = 2.07 while the diversity index for several tropical forest Division, Bangladesh is 1,735 (Dey and Akther) while the Shannon-Wiener forest diversity index Xisshuangbanna tropical rainforest, China and humid tropical forest Mizoram northeastern India are 3,45., 4.08, 4.37 respectively.

The results of quantitative analysis on all sampling plots showed that Margalef's species richness index was in the medium category with a value of R = 2.82. The species richness index describes the number of species in a community, in this case, a forest. Under the calculation of the diversity index (H) which is categorized as moderate, the species richness index relatively follows the value of the diversity index because the relationship is directly proportional between the two. The more the number of species or richness, the higher the level of diversity (Magurran, 1988).

Table 4. Index of Dominance, Richness and Evenness

Scientific Name	Dominance	Richness	Evenness
Diospyros celebica	0.01	R = 2.82	E = 0.94
Aleurites Moluccas	0.01		
Petrocarpus Indicus	0.06		
Felicium Decipiens	0.01		
Atrocarpus Heterophyllus	0.03		
Mangifera indica	0.00		
Lansium domesticum	0.00		
Ficus benjamina	0.00		
Gmelina arborea	0.00		
	C = 0.14		

The results of the calculation of the species evenness index E = 0.94 which means it is included in the medium category with a stable community. This is also related to the level of diversity and dominance of species at all observation stations. The species evenness index expresses the degree of evenness of individual wealth in each species. If each species has a relatively equal number of individuals, the level of species evenness is maximum. Concerning the dominance index, which is categorized as moderate, it means that there is no significant dominance of a species in an area, so the value of evenness will range from moderate to high

categories, and in this study, the Manado State University forest area has species evenness in the moderate category and a stable community (Wahyuningsih et al., 2019).

Light Intensity as an Environmental Factor

The environment is an external factor that affects the growth of a plant species. One of the environmental factors whose influence is very important for plant growth is light intensity. Measurement of light intensity at the observation station was carried out using the Lux Light Meter application at each observation plot. Data regarding the results of light intensity measurements can be seen in Table 5.

Table 5. Light Intensity

Sample's Location	Light Intensity (Lux)
Station 1: Faculty of Economics	3365
Station 2: Faculty of Mathematics, Natural and Earth Sciences	3134
Station 3: Faculty of Sport Sciences	3596

Based on the data in Table 5, it is known that the station with the highest light intensity is the third station with an intensity of 3596 Lux and followed by the first and second stations with light intensities of 3365 lux and 3134 lux. When connected with the data in Table 1, it is known that the second station has the highest number of species and the highest number of individuals compared to the other 2 stations. This is because the area gets light intensity that suits the ideal growing conditions for some species as well as because in that area there are indeed many canopy plants with varying tree heights that affect the available light intensity received to the surface to affect the level of photosynthesis and impact the growth, survival, and adaptation of a plant (Nugroho, 2020).

Conclusion

Forestry plants identified at 3 stations with 9 observation plots in the Manado State University forest area were 17 individuals with 9 species including *Diospyros celebica, Aleurites moluccas, Petrocarpus indicus, Felicium decipiens, Atrocarpus heterophyllus, Mangifera indica, Lansium domesticum, Ficus benjamina* and *Gmelina arborea* with Shannon Winner diversity index H' = 2.07 which means it is included in the medium category.

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